Informal Letter to D. Paquette from A.J. Stevens on 03/23/98.

Quantities Estimated Associated with Soil Activation Near RHIC Collider Rings.

Estimates based on Safety Envelope Limit of 4 times design intensity and operation for 38 weeks a year at 100% efficiency.

I. Quantities Estimated

Activity "in a year" is estimated, which is defined as:

$$\left.\frac{dN}{dt}\right|_{t=0} = \frac{N_0}{\tau}$$

where N_0 is some radionuclide production or production concentration per year and τ is mean lifetime.

For ^{3}H τ = 17.7 years = 5.58×10^8 seconds. For ^{22}Na τ = 3.75 years = 1.18×10^8 seconds. Convert to Curies using 1 Ci = 3.7×10^{10} dis./second. Then,

$$\frac{dN}{dt}(^3H) = 4.84 \times 10^{-20}\ N_0\ Ci\ /\ year$$

$$\frac{dN}{dt}(^{22}Na) = 2.29 \times 10^{-19}\ N_0\ Ci\ /\ year$$

All Estimates use CASIM star density. Measured production rates are .075 atoms ^{3}H per star and .02 atoms ^{22}Na per star.

II. Maximum Activity Concentration in Soil

(A) Dump: Max. star density 6.1×10^{10} stars/cc-year

This star density produces 4.575×10^9 ^{3}H atoms/cc-year and 1.22×10^9 ^{22}Na atoms/cc-year

Activity from **I** above is:

$$\frac{dN}{dt}(^3H) = 221\,pCi / cc(soil) - year$$

$$\frac{dN}{dt}(^{22}Na) = 279\,pCi / cc(soil) - year$$

Note: Maximum leachable concentration of ^{22}Na is .075 time above concentration.

(B) Collimators: Max. star density 1.4×10^{10} stars/cc-year

All quantities **lower** than in II(A) by a factor of 4.36 which is simply the ratio of maximum star densities.

III. Total Radionuclide Production

This adds dumps and collimators integrated over all soil.

^{3}H atoms/year = 4.1×10^{17}

^{22}Na atoms/year = 1.1×10^{17}

Activity from **I** above is:

$$\frac{dN}{dt}(^3H) = 19.8\,mCi / year$$

$$\frac{dN}{dt}(^{22}Na) = 39.8\,mCi / year$$

Note: Maximum leachable concentration of ^{22}Na is .075 time above activity.

IV. Activity Concentration in Groundwater

This can only be estinmated in the context of some model. The model of Ed Lessard in the AGS SAD has been adopted. The key elements of this model are:

(1) Leaching is due to rain.

(2) Quantities are averaged over time.

(3) Water in some volume of soil with vertical dimension 43 cm. is re-charged 12.8 time per year. This assumes an average annual rainfall of 55 cm. and that 10% of soil volume is occupied by water.

(4) No dilution (radionuclide concentration in water is enhanced by ×10 compared to soil concentration; this is just the 10% volume occupied by water in the soil).

In this model, 1.5×10^{11} stars/cc(soil)-year corresponds to the following maximum activity concentrations in groundwater: 4.17×10^{5} pCi/l (water) for ^{3}H and 5.0×10^{4} pCi/l (water) for ^{22}Na.

(A) Dump

The Max. star density 6.1×10^{10} stars/cc-year gives:

$$\frac{dN}{dt}(^{3}H) = 1.70 \times 10^{5}\ pCi / l(water) - year$$

$$\frac{dN}{dt}(^{22}Na) = 2.03 \times 10^{4}\ pCi / l(water) - year$$

(B) Collimators: Max. star density 1.4×10^{10} stars/cc-year

All quantities **lower** than in IV(A) by a factor of 4.36.

V. Mitigation by Liners

Liners are sized (in both transverse and longitudinal directions) to achieve a nominal reduction in radionuclides leachable by rainwater by a factor of 200. Taking credit for a factor of 100 gives:

$$\frac{dN}{dt}(^{3}H) = 1.70 \times 10^{3}\ pCi / l(water) - year$$

$$\frac{dN}{dt}(^{22}Na) = 2.03 \times 10^{2}\ pCi / l(water) - year$$

at the dumps. Concentrations at the collimator are, as usual, a factor of 4.36 lower.